



# Climate Change: Impact on Fauna and Fishing Activity of River

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## Abstract

The change in climatic conditions is a phenomenon both manmade and natural. Climate change not only affects human life but it has a very hazardous impact on the riverine aquatic ecosystem also. Due to the temperature rise, several hydrological parameters have been changed and developed a negative impact on aquatic life. The change is like the migration of aquatic organisms due to destruction of feeding and breeding habitat, early maturation in fish, reduction in water level, and change in the catchment area. Reduction in primary productivity is the major cause of reduction in fish stock size. Industrial waste disposal is also one of the major stressors for an aquatic ecosystem. Fishing behavior and pattern got changed in every river system due to the destruction of the feeding and breeding ground maturation period of fish. Climate change is a continuous process and in this situation introduction of genetically modified organisms, river ranching programs, and modifications in riverine fishing policy may be able to secure fisheries resources sustainably in the river system.

## Keywords

Climate change · Aquatic system · Thermal regimes · Aquatic fauna · Fishing

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## 1 Introduction

Climate change is a very serious issue for the aquatic environment (Mohanty and Mohanty 2009; IPCC 2007). It has a huge negative impact on inland fisheries and aquaculture practices in India. In inland water bodies, riverine biomass is highly affected by climate change like increase in water temperature, reduction in the level of water in the river, changes in fish feeding and breeding ground, reduction in the availability of natural live food, reduction in fish growth, reduction in fish stock size, etc. which directly or indirectly develop impact on fishermen whose livelihood is fully dependent on the riverine catch. Fisheries are already a rapidly developing sector but due to overexploitation of riverine fisheries reduction in fish stock size is one of the major drawbacks of riverine capture fisheries. A riverine fishery faces lots of difficulties in maintaining natural sustainable conditions due to the impact of climate change.

Due to industrialization and urbanization riverine ecology is already under stress and climate change developed additional stress on the system. The growing population of a country that is settled nearby the river is fully dependent on riverine natural resources to fulfill their requirements and enhance their livelihood and is considered vulnerable due to climate change. The riverine system of India is having one of the richest diverse aquatic resources in the world. This country is having 12 major river systems with a total catchment area of 252.8 million hectares. The Ganga and Brahmaputra river system is considered as largest because it holds a 110-million-hectare catchment area.

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## 2 Impact on Hydrology

The environment of riverine aquatic organisms is greatly influenced by a change in water temperature, and this happens due to the impact of change in climate which alters atmospheric energy and heat exchange (Caissie 2006). Climate change not only affects the atmospheric and aquatic systems but also has a huge direct impact on runoff through precipitation. The flow of rivers derives from precipitation which helps to know the water supply and the course by which precipitated water reaches the river channel (Poff et al. 1997). The catchment area of the river is also reduced due to changes in annual runoff and precipitation (Tang and Lettenmaier 2012).

The increase in water temperature by changing climate causes a decrease in discharge up to 20–40% which again gets affected by higher temperature due to reduction in water level (Van Vliet et al. 2011). The ecosystem of the river gets disturbed due to climate change because many fish species changed their habitat.

Several aquatic organisms are very much exposed to human being-induced pressure (Woodward et al. 2010). Of all the aquatic organisms fish are ectothermic. Hence, they are directly dependent on the atmospheric and water temperatures.

Water pollution due to industrialization is also one of the major causes of disturbance in the riverine ecosystem. Some of the fish species are lost due to changes in water quality and due to a lack of required quality habitat for feeding

and breeding (Reyjol et al. 2007). Greenhouse gas emission which is initiated by activities of human beings also imparts an unpredictable change in the aquatic environment mainly to the diversity of freshwater aquatic organisms (Dudgeon et al. 2006; Woodward et al. 2010).

## 2.1 Water Temperature

Variation in temperature of the riverine ecosystem is one of the major concerns for the habitat of organisms (Brett 1956). Due to the ectothermic nature of fish, all life stages, i.e., from juvenile to adult, are fully dependent on their ambient temperature. According to Caissie (2006), the factors, which are responsible for the change in riverine water temperature, are:

1. Condition of atmospheric air
2. Discharge of stream
3. Land topography
4. Streambed

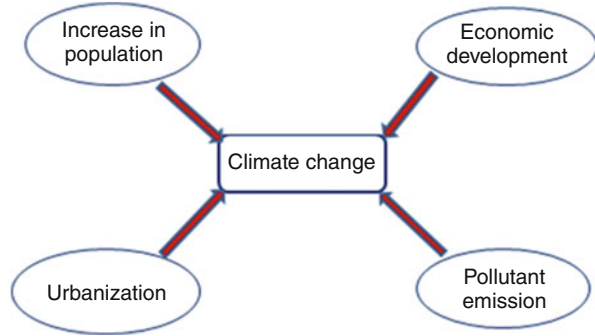
The condition of atmospheric air is highly responsible for the exchange of heat in the water mass of rivers. The discharge of the stream estimates the amount of water flow in the river. Generally, narrow rivers get fast affected by heating and cooling due to less amount of water in a particular area. The air temperature variation is found in different geographical areas. Streambed of rivers depends on several factors like land topography, water temperature, water pressure, etc. (Caissie 2006).

There is no linear trend found in temperature variation in the river. If the river is small and has less depth then there will be higher water temperature than larger rivers in the same geographical area (Caissie 2006). In a chemo-physical environment, water temperature plays a very significant role for an aquatic organism. Lower temperatures were observed during morning hours and higher temperatures were observed during the afternoon. Daily minimum temperatures can be observed in the morning hours and maximum temperatures in the late afternoon (Woodward et al. 2010).

## 2.2 Interactions of Climate Change with Other Stressors

Other than climate change non-climatic drivers also act as a stressor for the aquatic environment and organisms. The non-climatic drivers like increase in population, urbanization, emission of pollution due to industrialization, and economic upliftment affect the aquatic ecosystem (Dudgeon et al. 2006; Nelson et al. 2006).

The groundwater recharge of fresh water and increase in the chances of floods are also affected due to deforestation and urbanization. All these changes affect both agricultural and aquaculture practices (Bates et al. 2008). Thus, in the future, land availability will be a major concern for freshwater agriculture and aquaculture

**Fig. 1** Non-climatic drivers

systems. The loss of water of about 90% due to irrigation alone severely impacts freshwater availability for aquaculture, humans, and ecosystems (Fig. 1) (Döll 2009).

The human impact like the generation of hydropower also develops huge pressure on riverine ecosystems. The change in river flow may be one of the reason for change in stock of fish and other organisms and disturbing discharge regimes on hourly time scale (Poff and Zimmerman 2010). Due to changes in streambed and stream flow also got affected by changes in climatic conditions.

### 3 Ecological Impacts of Thermal Regimes on Aquatic Fauna

All the aquatic organisms including fish are affected by the temperature of the surrounding water starting from the egg to the adult stage (Brett 1956). Fry (1947) gives five main categories of effects of temperature on fish:

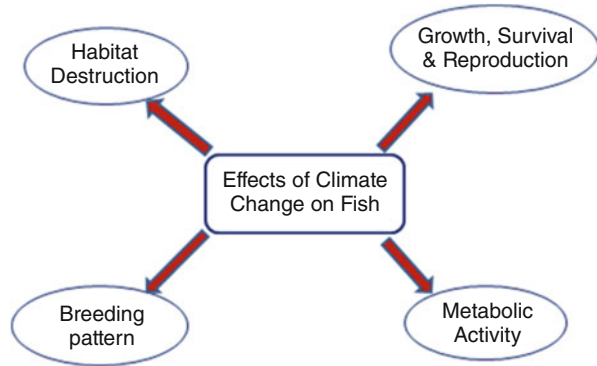
1. Change in metabolic and development rates
2. Effect on movement and disturbance
3. Change in movement pattern
4. Reduction in immune response
5. Fish may die

The impact of temperature on aquatic fauna occurs at different organizational levels, i.e., from individual to population or community (McCullough et al. 2009; Woodward et al. 2010). Therefore, the change in climate affects almost everything about individual fish including suitable habitat, rate of survival, breeding, hatching, feeding, physical condition, physiological condition, and metabolic activity (Fig. 2).

The temperature tolerance level of organisms will determine the adoption level in a changing environment. In this changing climatic condition, introduction of Genetically Modified Organisms (GMOs) is the only solution to overcome all these existing problems of climate change.

According to Magnuson et al. (1997), aquatic organisms can be classified into three thermal guilds:

**Fig. 2** Effects of climate change on fish



1. Cool-water species (<20 °C)
2. Cold-water species (20–28 °C)
3. Warm-water species (>28 °C)

The behavior of fish will get changed if their surrounding environment temperature will get changed. The fish showing the same behavior used to share the same habitat, but a due climate change has disturbed their habitat. Microhabitat has been developed for the temporary settlement of organisms in changing climatic conditions. This not only affects the aquatic fauna but also affects the fishermen and their livelihoods (McCullough et al. 2009). Due to non-climatic stressors, some aquatic organisms would migrate from their original place to other suitable places but not very far from their original habitat. Climate change has disturbed the habitat of several aquatic organisms at all levels of life stages permanently. Thermal stress is also involved in the reduction of disease resistance, changing feeding, behavior, etc.

At the higher level, several fish species' stocks have been disturbed including abundance, productivity, and genetic diversity. If this condition remains for a longer period there will be many fish species migrating to different levels, i.e., higher or lower streams. The fish species coming under endangered is also due to changes in climatic conditions (Bässler et al. 2010; Sauer et al. 2011; Dirnböck et al. 2011; Vitecek et al. 2015; Rabitsch et al. 2016). Generally, climate determines bio-geographical distribution patterns (Reyjol et al. 2007), and hence, climate change will have huge impacts on aquatic communities. Comte et al. (2013) observed distribution changes for fish due to climate.

## 4 Impact on Fishing

Climate change not only disturbed riverine hydrology and their fauna but also developed a negative impact on sustainable fishing practices. In general, due to the rise in surface water temperature fish stock changed. This change not only disturbed fish species availability but it also changed fish breeding time, fish habitat, growth

and feeding pattern. Due to all these changes in riverine fauna fishermen faced several problems like:

1. Reduction in catch per unit effort
2. Reduction in fishing efficiency of gear
3. Loss of fish species diversity
4. Less catch with the smaller size of fish
5. More energy and time involved in fishing practice, etc.

The livelihood of most of the fishermen is fully dependent on fish caught from the river. Due to the hazardous impact of climate on riverine fisheries resource the amount of catch has been reduced and the socio-economic status of fishermen is in danger. Now, some fishermen try to move towards other occupations to fulfill the demand of their families and to enhance their livelihood. Some fishermen who are still fishing in this occupation have reduced the mesh size of the gear without bothering about the ecosystem and sustainability of resources to harvest more amount of catch per unit of catch. Due to the reduction in mesh size of gear, gear became unselective and more than 50% of catches are coming under bycatch which is now a very serious issue for the sustainability of the aquatic resource.

Due to changes in breeding behavior and patterns, fishermen also used to harvest mature fishes, i.e., brooders. Over-exploitation which includes recruitment overfishing and growth overfishing of aquatic resources is also a major concern. Sustainability of resources is very important, and it can only be possible by enhancing fish stock and reducing overfishing. It can be done by involving a river ranching program, a fishing ban period during the breeding time of fish, changes in design, and construction of gear including mesh size and netting material.

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## 5 Conclusion

Climate change is a hidden hazardous continuous phenomenon that disturbed human and aquatic life. Besides all these, it has a huge impact on the riverine ecosystem. The major effect of climate change is a rise in the temperature of air and water. Due to the increase in riverine water temperature, several changes occurred such as destruction in feeding and breeding ground of several aquatic organisms, change in growth, survival, and maturation period, change in the food chain and food web, change in fishing pattern, and change in the sustainability of riverine fisheries resource due to increase in bycatch and overexploitation. It is not easy to mitigate the entire above-listed problems raised due to change in climate, but we can maintain the riverine fisheries resource sustainable by the introduction of a river ranching program and modifications in fishing policy like mesh size regulation of gears, fishing quota, fishing ban period, etc. Besides all these, the introduction of Genetically Modified Organisms (GMOs) which can sustain climate change stressors in riverine conditions can make fisheries resource sustainable.

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